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Dear Editor,

We read with interest a recent paper by Glazier and Mehdizadeh [1] on the application of biomechanics within applied sport settings. Their article challenges several conventional techniques and assumptions purportedly prevalent within the sports biomechanics domain. Consequently, two main conclusions are drawn; firstly, that it is inherently flawed to rely on group-based data when working with an athlete to modify their already existing movement pattern and, secondly, that biomechanists and coaches should be more circumspect when interpreting the results of biomechanical research because studies do not account for the pre-existing characteristics of the specific athlete in question. Within the authors' arguments, several important factors are realised which attest to the ongoing difficulties and complexity that so well defines *real-world* practice in sport [2, 3]. In this regard, we welcome such attention as a contrast to the often too reductionist approaches of laboratory-based research which lacks translational impact (see also Gray [4] from a motor control perspective). Despite the novel and insightful epistemological position adopted by the authors, however, we do not believe that the conclusions reached from this current opinion are novel, nor particularly current. Furthermore, perhaps because of the unidisciplinary or limited epistemological stance taken, the paper may lack translational impact. Accordingly, we wish to take this opportunity to review these arguments and offer what we hope is a useful extension where possible.

Addressing the first argument, the clear statement is that group-based analyses are inappropriate in these circumstances, therefore implying that intra-individual treatment of data are preferred. This has been previously stated several times (e.g., Carson and Collins [5, 6]), although perhaps in recognition of the combined interaction between constraints [7] that

have shaped each athlete's unique technique and not predominantly from a biomechanical perspective. Indeed, reflecting this necessity, the vast majority of empirical studies which address the task of refining an athlete's already well established technique *do* employ individual case study designs [8-11]. Furthermore, previous consideration of a biomechanist's (or at least biomechanics') role within the technical change process has identified the importance of understanding these unique movement properties:

> "What must be determined is whether these technical idiosyncrasies are 'errors' or in fact causative of successful executions? If the biomechanist is not well acquainted with the particular athlete's playing style, team role and technical capabilities, coach-guidance will be essential in translating what would ideally be a six degrees-of-freedom analysis into technical principles that are widely used by athletes and coaches. Failure to establish even a general qualitative idea about potential target variables [skill elements in need of change] from those working closest to the athlete can, with tremendous frustration, lead to the situation of 'trying to find a needle in a haystack'". [12]

Interestingly, this point is also reiterated by Glazier and Mehdizadeh [1].

Accordingly, this quote provides a useful segue into evaluating the second conclusion offered, the circumspection of empirical data as a (perhaps suggested as *the*?) source to inform applied practice. To highlight further deficiencies when attempting to translate solely biomechanical research within the applied setting, Smith et al. [13] revealed that experienced golf coaches' perceptions of important swing kinematics had been insufficiently investigated by empirical research. Moreover, the events considered to be of interest by these practitioners also lacked coverage within the literature. In other words, biomechanics research has potentially overemphasised the importance of a few *specific* movements rather than appreciating the *holistic* technique; something the golf coaches in the Smith et al. study

were acutely aware of. We completely agree with Glazier and Mehdizadeh [1] that, currently, it remains a significant challenge to identify with certainty, using biomechanical instruments (alone), the *exact* movement in need of change. As such, and even *if* there were to be a better method of approaching the problem, coaches *should* also be consulted as part of the identification process and *definitely* as part of the subsequent intervention [14]. Positively, Smith et al. [13] acknowledged the necessary link from practice to theory and suggested that future research should be informed by the knowledge of expert practitioners (cf. Christina [15]).

In fact, it is also possible to extend the criticism towards sport biomechanics research for lagging behind other domains (e.g., clinical biomechanics [16, 17]) in terms of the systems by which joints/movements have been defined, modelled and measured. Specifically, some authors have raised concern that overuse of global co-ordinate systems and/or reporting movement in a limited number of planes reduces the functional meaning of data [18, 19] as well as the capacity of the athlete to operationalise the changes suggested . In short, before any comparisons or correlations are calculated, it is surely best practice to ensure the movements captured are anatomically representative and changes are understandable.

Regarding the change diagnosis, the authors identify "It is likely that an athlete will find it difficult to reliably adopt the specified optimum technique if the basin of the existing attractor is deep and/or if the existing and optimum attractors are in different regions of the dynamic landscape". We completely agree that the process of change is difficult and a challenge that should not be undertaken without due diligence in weighing up the various options available. However, if a decision to change technique *is* arrived at, it is important to recognise the need for an interdisciplinary *and* multifaceted approach. Importantly, advances specific to this challenge have been addressed within the literature to explain what, how and

why certain steps need to be taken [5, 6, 8-12, 20-25]. In short, skill refinement is not a solely biomechanical issue nor parsimoniously addressed from a dynamical systems approach alone. At the very least, psychological constructs, including the athlete's cognitive understanding of the change, the reasons for it and how automaticity will be regained are vital considerations for this important applied issue.

Compliance with Ethical Standards

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Conflicts of Interest

Howie J. Carson and Dave Collins declare that they have no conflicts of interest that are directly relevant to the content of this letter.

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